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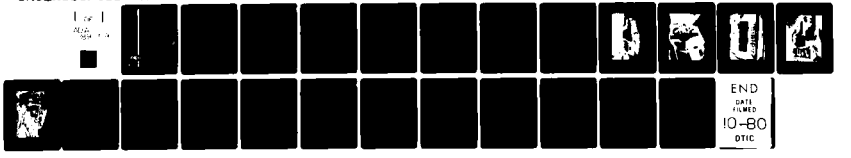

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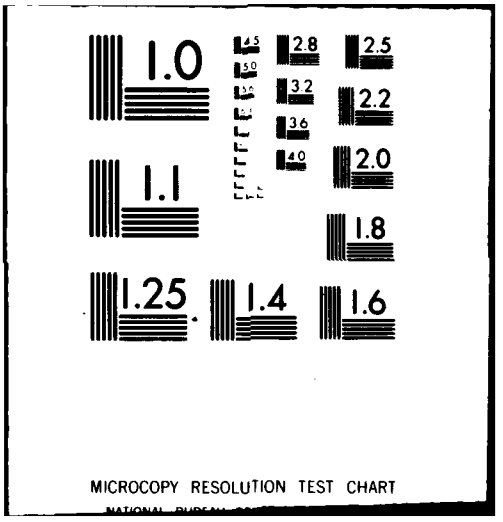
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Report 2304

VERIFICATION TEST OF THE CHANGE-OF-PACE STATION WAGON

by
Edward J. Dowgiallo, Jr.
Ivan R. Snellings
and
William H. Blake

July 1980

U.S. ARMY MOBILITY EQUIPMENT
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The Change-of-Pace, an electric four-passenger station wagon, was tested at MERADCOM to verify conformity to the Department of Energy Performance Standards for Demonstrations, published in the Federal Register, 30 May 1978, Part V. The Change-of-Pace is manufactured in Cleveland, Ohio, by Electric Vehicles Associates. It is a converted AMC Pacer station wagon. It is powered by 20 6-volt batteries that are connected to the motor through an SCR controller actuated by a foot pedal to control motor speed. The 22-horsepower motor drives the rear wheels through an automatic transmission. Regenerative braking is provided.

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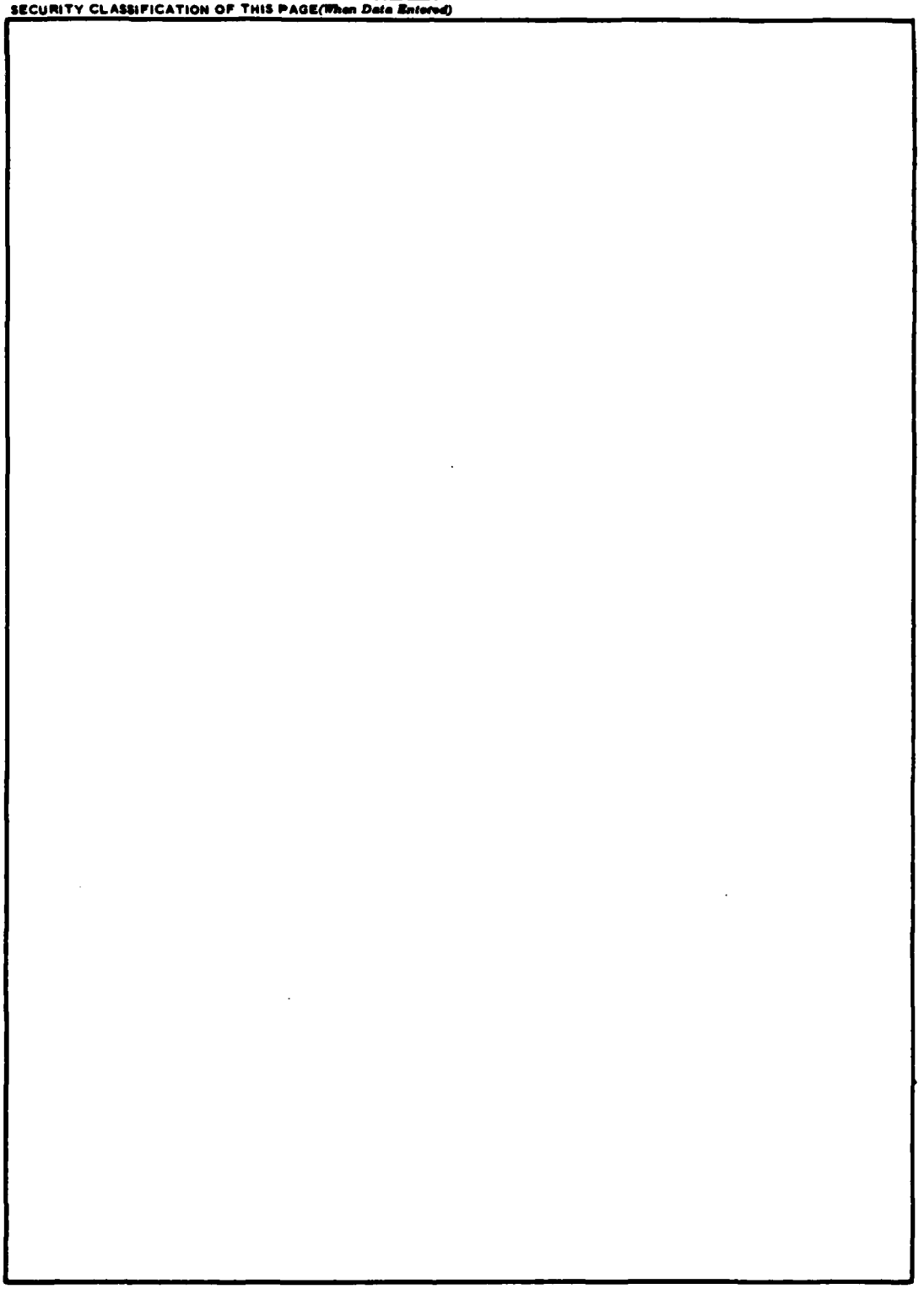

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I. SUMMARY

The Change-of-Pace, manufactured by Electrical Vehicle Associates (EVA), was tested during the period from 14 July 1978 to 11 September 1978. Complete test results are contained in Section V. Part of the verification test results are summarized below:

Acceleration:	50 km/h (31.1 mi/h) in 13 s.
Range:	51 km (31.7 m) driving 86 cycles of SAE J227a/type C driving cycle.
Forward Speed:	80 km/h (49.7 mi/h) for 39 min on MERADCOM Track with 5-percent grade.
Gradeability at Speed:	At 25 km/h (15.5 mi/h) can traverse 13.8-percent grade (calculated)
Gradeability Limit:	27.9-percent grade for 20 s (calculated).

II. INTRODUCTION

The EVA Change-of-Pace electric vehicle was operated to verify conformity to the Department of Energy "Performance Standards for Demonstrations," published in the Federal Register, 30 May, 1978, Part V. The results of that testing, as performed by the U.S. Army Mobility Equipment Research and Development Command (MERADCOM), as well as other descriptive data concerning the vehicle, are presented in this report.

III. OBJECTIVES

The objectives of this test were to examine the EVA Change-of-Pace for suitability of those aspects of vehicle and component operating characteristics as outlined by the Department of Energy's "Performance Standards for Demonstration."

IV. DESCRIPTION OF TEST VEHICLE

The EVA Change-of-Pace Electric Station Wagon is an electrified version of an AMC Pacer wagon, converted by Electric Vehicle Associates, Inc., 9100 Bank St., Cleveland, OH 44125. The vehicle has a curb weight of 1941.4 kg (4280 lb) and loaded with cargo and driver has a gross vehicular weight of 2177.3 kg (4800 lb) (Figure 1).

The EVA Change-of-Pace Station Wagon (Pacer) comes equipped with standard lighting, windshield wipers and washers, speedometer, and odometer. The heater and defroster obtain hot air produced by an Espar gasoline-fired hot-air heater, rated at about 2000 Kcal/h (8000 Btu/h), and fueled from a 2½-gal fuel tank. Instrumentation peculiar to electric vehicles includes a 0- to 120-volt three-color band voltmeter, an amperemeter, 0-350A, and an auxiliary battery voltmeter (Figure 2).

The Pacer comes equipped with a Chrysler 904 3-speed automatic transmission with a lockup torque converter. It has front coil spring and rear leaf-spring suspension, with an anti-sway bar, heavy-duty shocks and an added rear leaf modifying the rear suspension. The gear ratios are 2.45:1, 1.45:1, and 1.00:1.

Braking in the Pacer is provided by hydraulic front-disc and hydraulic rear-drum brakes, with a mechanically actuated rear-drum parking brake. Regenerative braking is available as an option. The vehicle comes equipped with Michelin 6.70 R14 XAC tires, inflated front and rear to 3.36×10^3 torr (65 lbf/in.^{2}).

The heart of the Pacer is, of course, the propulsion system, and the batteries for the Pacer are 20 145-ampere-hour rated Trojan J244 lead acid, deep-discharge batteries.

These batteries are fused by a Fusetron, FRN250 ampere fuse. The auxiliary battery is a 25-A-h, 12-V unit (Figures 3, 4, and 5). The motor in this propulsion system is an EVA Series wound motor, rated at 120 V, 200 A continuous, 16.4 kW (22 hp). The maximum rated r/min is 4599. Finally, to control the motor the Pacer uses a Cableform Pulsomatic MK10 SCR-type controller. This unit is rated at 140-V d.c., 135-A continuous, 300-A for 3 min maximum service (Appendix).

Figure 1. EVA change-of-pace station wagon.

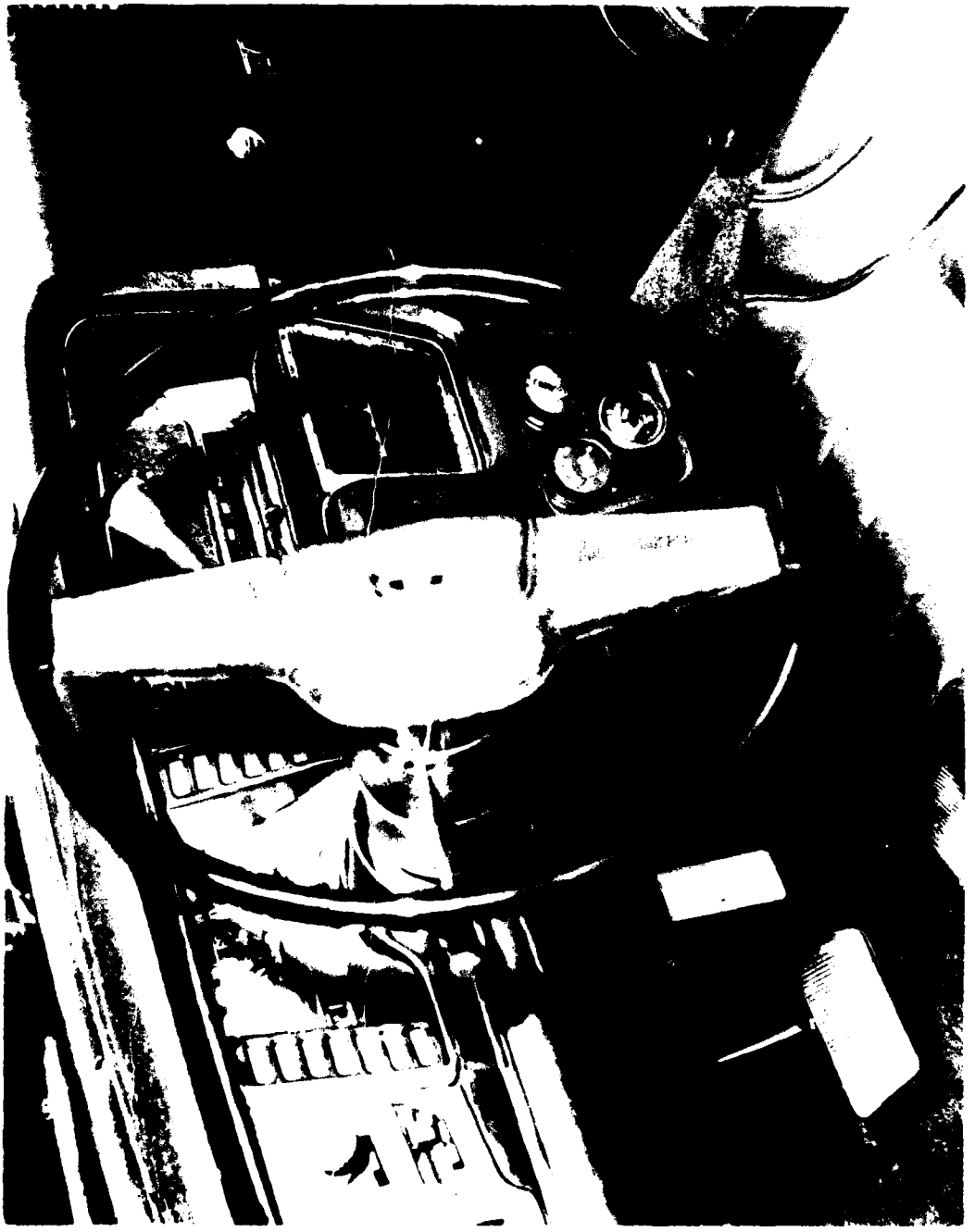

Figure 2. Dashboard of the change-of-pace station wagon.

Figure 3. Rear battery compartment.

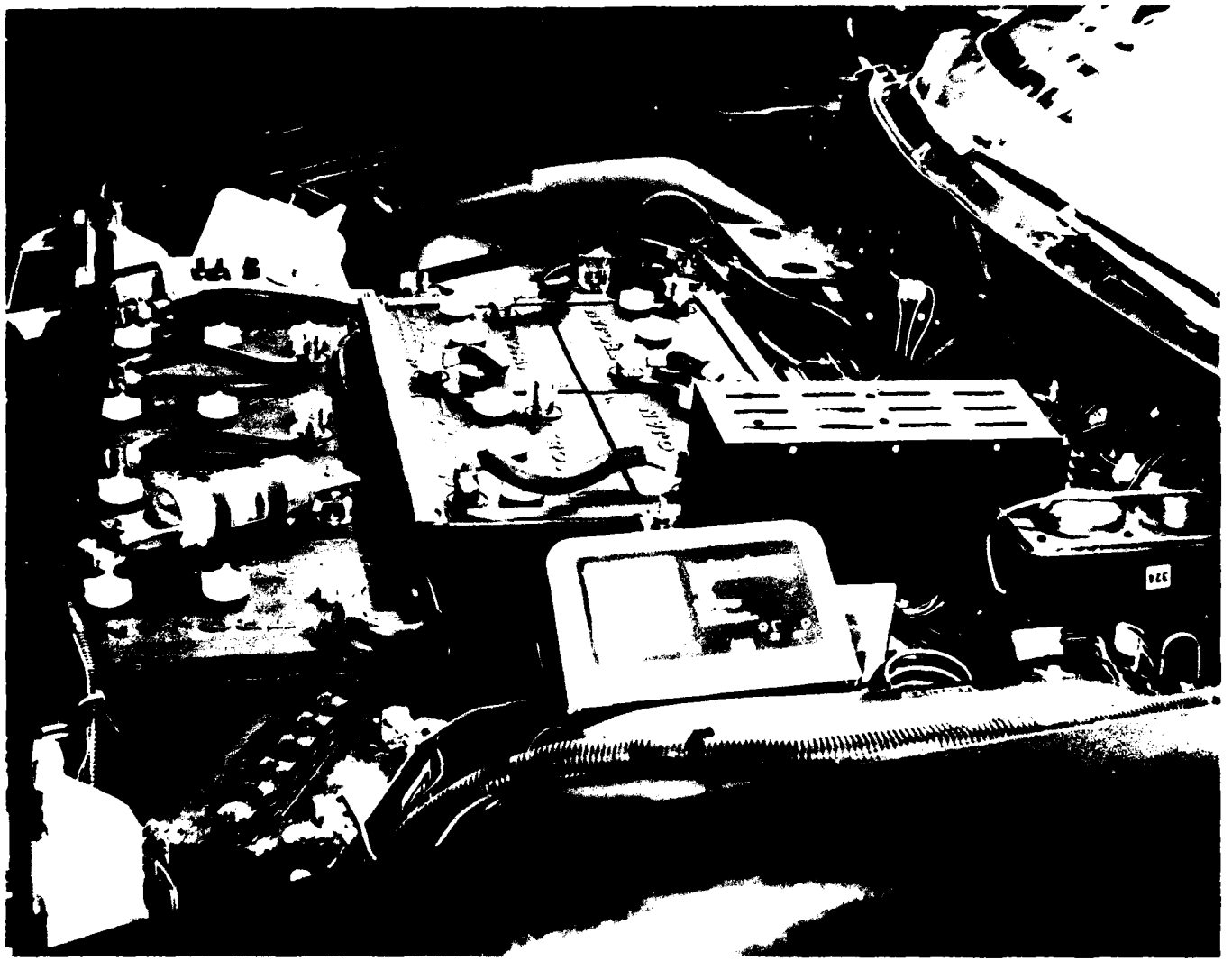

Figure 4. Front battery compartment with SCR controller and auxiliary battery charger.

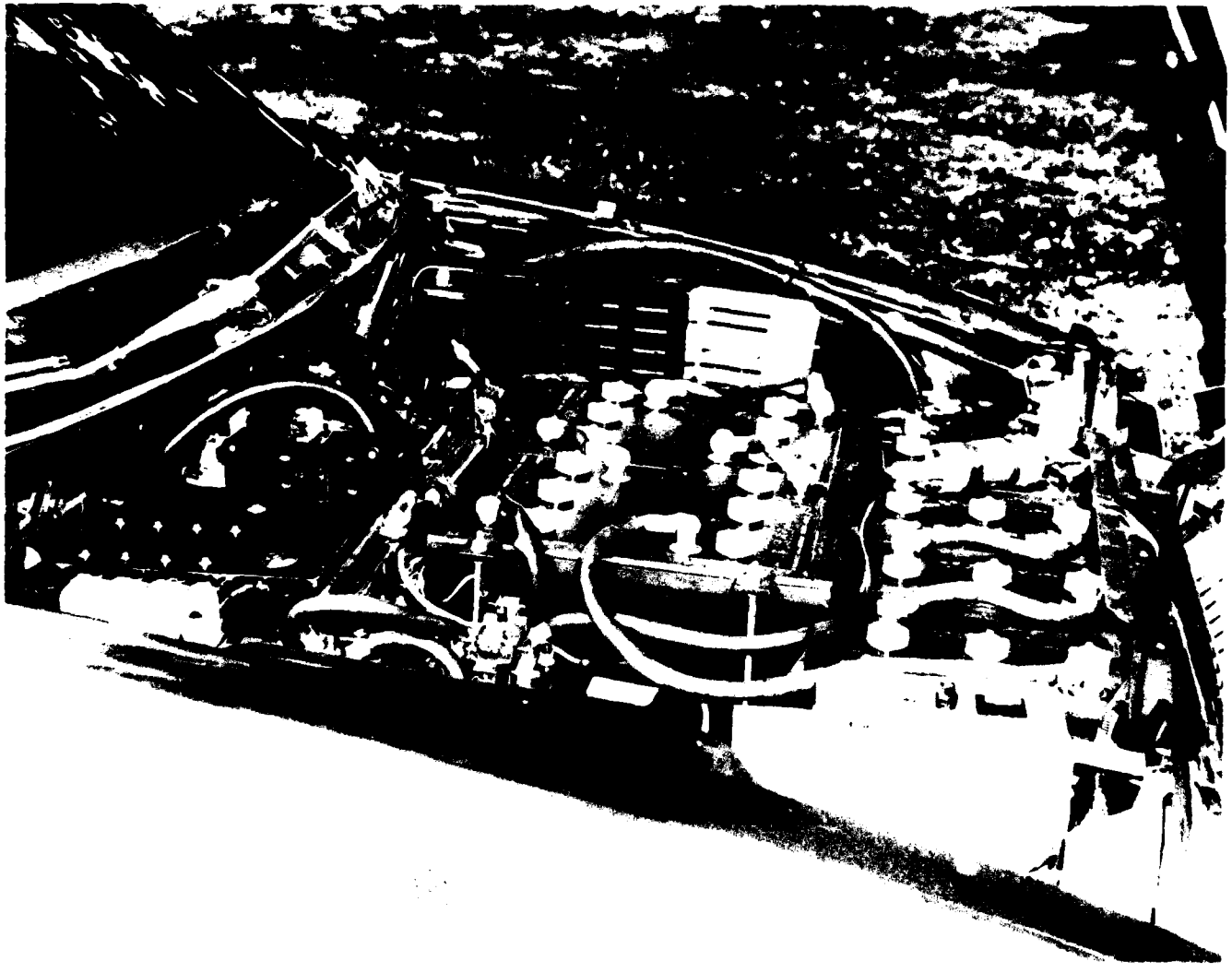

Figure 5. Front battery compartment with SCR controller and traction battery charger.

V. TEST RESULTS

The following are the results of the Verification Test performed at MERADCOM during the period of 14 July 1978 to 11 September 1978. Paragraphs are referenced to the DOE "Performance Standards for Demonstrations" criteria.

(a) Acceleration. 50 km/h in 13 s.

(b) Gradeability at speed. At 25 km/h can traverse a 13.8-percent grade based on calculation from acceleration tests at 80-percent depth of battery discharge (DOD).

(c) Gradeability limit. Vehicle should start and climb forward on a 27.9-percent grade for at least 20 s based on drawbar pull tests at 80-percent DOD.

(d) Forward speed capability. Maintained 80 km/h for 39 minutes on MERADCOM test track with a 5-percent grade.

(e) Range. SAE J227a C cycle on level (±1%) terrain, 51 km, and 86 cycles. The auxiliary battery was discharged before completion of this test due to an inoperative traction battery-powered charge circuit. The battery was replaced with a fully charged one and the test was completed. The manufacturer now claims to have an operating charge circuit.

(f) Battery recharge time. After an 80-percent discharge, recharged with charger model Battery Marshall Mark 3 (220 VAC, 50 A) on board the vehicle for 10 h; after recharge, vehicle operated for 50 km to SAE J227a C cycle regime.

(g) Recharge control. Timer, with a maximum setting of 16 h.

(h) Energy consumption. Only nonelectrical energy use is optional gasoline-fueled heater.

(i) Battery life. Warranty period of 12 mth. Battery type — TROJAN MODEL T-135 lead acid, 75-A for 135 min. Battery consisted of 60 cells connected in series in 20 modules, nominal voltage was 120 V.

(j) State-of-charge meter. Voltmeter, three color bands.

(k) Odometer. Yes.

(l) Passenger comfort heater. Optional.

(m) Documentation. Satisfactory. The following were provided: User manuals, maintenance (service) manuals, and parts lists.

(n) Emissions. Did not evaluate.

(o) Safety. The Department of Transportation is performing these evaluations; however, MERADCOM performed the following limited checks:

(1) Electrical isolation. The electrical propulsion circuit is isolated by design; however, voltages above 50 V capable of sustaining currents greater than 60 mA were measured from a battery terminal to the frame. Electrical shocks to personnel occurred while they were measuring specific gravities even when only touching the battery cases. Battery manufacturers claim that leakage currents and voltages are conducted through acid vapors which have condensed on the battery cases during charge and discharge.

(2) Safety standards 208 and 301. The Department of Transportation will check compliance. Comments: Rear battery holddown brackets were too close to battery terminals.

(3) Battery caps were standard golf cart type. Flame-barrier characteristics were not tested.

(4) Ventilation of battery compartment. All battery compartments should be open during charge and adequate ventilation provided to carry off acid vapor and to avoid hydrogen-oxygen explosions. This should be scrupulously followed before closing the vehicle for a time after charging to allow residual hydrogen gas to dissipate.

(5) Battery emergency disconnection. No mechanically linked disconnect was provided. However, the vehicle has a master, normally open, contactor rated at 2000 A designed to break short circuits, which is key-switch operated and powered from the 12-V auxiliary battery. There are also two relays, rated at 1500 A each, that apply the battery voltage through the SCR controller to the motor. These contacts are normally open and are closed with power from the 120-V traction battery. The vehicle also has a torque converter and automatic transmission with a neutral shift position. The battery packs are each fused at 250 A.

(6) Parked temperature effect. Vehicle was parked for two 8-h periods at temperatures of -25° C and 50° C. Subsequent operation revealed no apparent damage to the vehicle or hazard to personnel.

APPENDIX

VEHICLE SUMMARY DATA SHEET

1. Vehicle Manufacturer Name and Address:

Electric Vehicle Associates Inc.
9100 Bank Street
Cleveland, Ohio 44125
216-524-8418

2. Vehicle Description

Name: Change-of-Pace
Model: Station Wagon
Availability: Out of production
Price: —

3. Vehicle Weight

Curb Weight: 1991 kg (4380 lb)
Payload Weight: 272.7 kg (600 lb)
Gross Weight: 2264 kg (4980 lb)

4. Vehicle Size

Wheelbase: 2.553 m (100.5 in.)
Length: 4.483 m (176.5 in.)
Width: 1.943 m (76.5 in.)
Headroom: 0.977 m (38.45 in.)
Legroom: 1.033 m (40.68 in.)

5. Auxiliaries and Options

No. Lights: 11
a. Head; Parking; Signal; Dome; Tail; Tag;
b. Backup; Stop; Emergency; Dash; Running Light

Windshield Wipers: Yes
Windshield Washers: Yes
Defroster: Yes
Heater: Yes
Radio: No
Fuel Gage: No
Ampmeter: Yes
Tachometer: No
Speedometer: Yes
Odometer: Yes
No. Mirrors: 2
Power Steering: No
Power Brakes: No
Transmission Type: Automatic

6. Propulsion Batteries

Type T-135
Manufacturer: Trojan
No. of Modules: 20
S/N: N/A
No. Cells: 60
Battery Voltage: 120V
AH Capacity: 168 A-H
Battery Size: H0.267 m (10½ in.) W01.84 m (7¼ in.) L0.267 m (10½ in.)
Battery Weight: 34.6 kg (76 lb)
Battery Age: New
Battery Rate: 75 A
Battery Cycles: 5 Cycles

7. Auxiliary Battery

Type: Lead/Acid
Manufacturer: Gould
No. Cells: 6
Battery Voltage: 12V
AH Capacity: 25 A-H
Battery Rate: 20 H

8. Controller

Type: SCR
Manufacturer: Cableform
Voltage Rating: 140
Current Rating: 135A, 300A max-3 min.
Size: H0.254 m (10 in.) W0.127 (5 in.) L0.610 (24 in.)
Weight: 22.7 kg (50 lb)

9. Propulsion Motor

Type: Series
Manufacturer: EVA
Insulation Class: H
Voltge Rating: 120
Current Rating: 200 A Cont.
HP Rating: 16.4 kW (22 hp)
Max. 5 Min. Rating: N/A
Size: 0.356 m (14 in.) 0.305 m (12 in.)
Weight: 109 kg (240 lb)
Rated Speed: N/A
Max. Speed: 4599 RPM

10. Body

Type: S/W
Manufacturer: AMC
No. Doors: 2
Type: Hinged
No. Windows: 3
Type: 2 crank; 1 swing
No. Seats: 3
Type: 2 bucket; 1 bench
Cargo Volume: 1.5 m^3 (52.45 ft^3)
Cargo Dimensions: 1.7x1.16x0.79 (m) (5.5x3.8x2.6) (ft)

11. Chassis

Type Frame: Unitized
Manufacturer: AMC
Type Material: Steel
Modifications: None
Type Springs: Coil (Front) Leaf (Rear with Added Leaf)
Type Shocks: Hydraulic
Axle Type Front: Independent
Axle Type Rear: Solid
Axle Manufacturer: AMC
Drive Line Ratio: 3.58:1
Type Brakes Front: Disc
Type Brakes Rear: Drum
Regenerative Brakes: Yes
Tire Type: Tube 8 PR.
Manufacturer: Michelin Radial
Size: 6.70 R14 x AC
Pressure: 448.2 kPa (65 PSI) Front and Rear

12. Battery Charger

Type: SCR
Manufacturer: EVA
On or Off Board: On
Input Voltage: 220
Peak Current: 50 A
Recharger Timer: Yes
Weight: 9.1 kg (20 lb)
Automatic Turn Off: Yes (Timer w/Voltage Sense)

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